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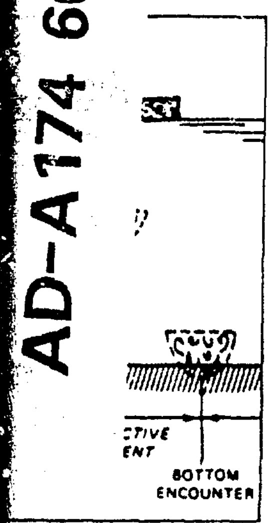

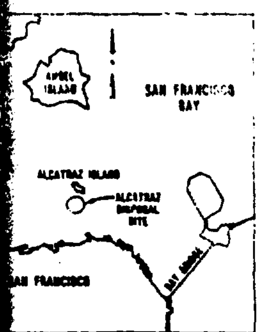

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ALCATRAZ DISPOSAL SITE INVESTIGATION

Report 2

NORTH ZONE DISPOSAL OF OAKLAND OUTER HARBOR AND RICHMOND INNER HARBOR SEDIMENTS

by

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Dredged material from San Francisco Bay has been disposed of at the Alcatraz Island open-water disposal site for many years. Since the disposal site lies in an extremely high energy area, historically it has been assumed that the vast majority of the disposed material moves with the current past the Golden Gate Bridge and is then carried out into the ocean. However, recent surveys of the disposal site have shown that a large mound of material, which creates navigation problems, has formed. Since a new dredging project in the area is expected to create approximately 5 million cu yd of new material to be disposed at the site over the next 2 years, a major concern is how much of the new material will remain within the disposal site and contribute to the existing mound.

To address the problem, a numerical model has been applied that computes the behavior of a dredged material disposal through three phases: convective descent, during which the

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disposal cloud falls under the influence of gravity; bottom collapse, occurring when the descending cloud impacts the bottom; and passive transport-diffusion, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation. The model accounts for land boundaries, depth variations, ambient current variations in three dimensions and in time, several sediment classes within the dredged material, and variations of ambient density profiles in time. A major limitation of the model is that erosion and subsequent redeposition of material deposited on the bottom are not modeled. Therefore, results from the numerical model were used only to provide the initial amount and distribution of material deposited within the disposal site. Analytic techniques were subsequently employed to analyze the erosional characteristics of the bottom deposits within the site.

Results of the study show that for both Richmond Inner Harbor and Oakland Outer Harbor sediments disposed of in the north zone of the Alcatraz disposal site, the majority of the material will initially deposit within the disposal site limits. Some reduction of within-site deposition is achieved by ebb-tide-only disposal.

PREFACE

The estimation of short-term fate for the open-water disposal of dredged material at the Alcatraz disposal site, documented in this report, was performed for the US Army Engineer District, San Francisco.

This report is Report 2 of a series. The first report was published as "Alcatraz Disposal Site Investigation," Miscellaneous Paper HL-86-1.

The study was conducted in the Hydraulics Laboratory of the US Army Engineer Waterways Experiment Station (WES) during the period July 1985 to June 1986 under the direction of Mr. Frank A. Herrmann, Jr., Chief of the Hydraulics Laboratory, and Mr. William H. McAnally, Jr., Chief of the Estuaries Division. The work was performed by Mr. Michael J. Trawle, Estuaries Division. Mr. Dave Stewart, Estuaries Engineering Branch, was the technician for this study.

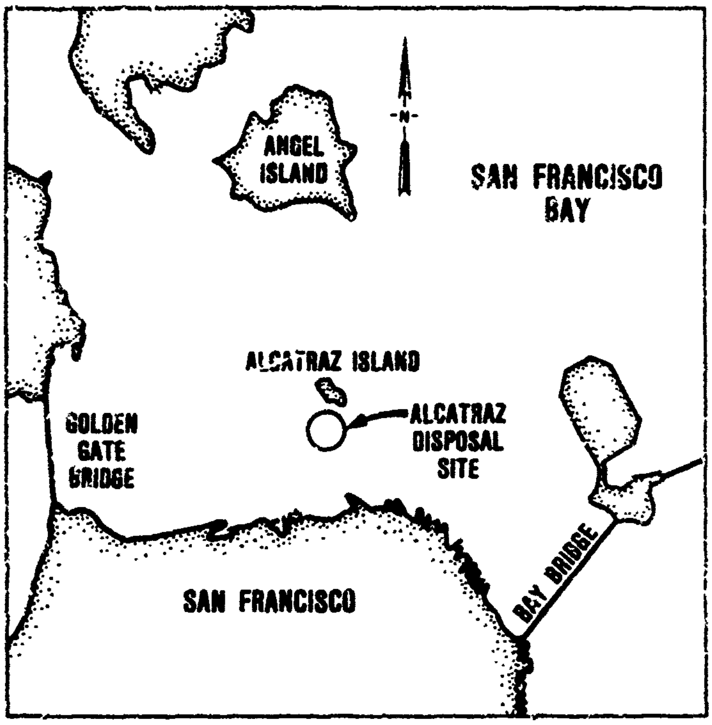
COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

CONTENTS

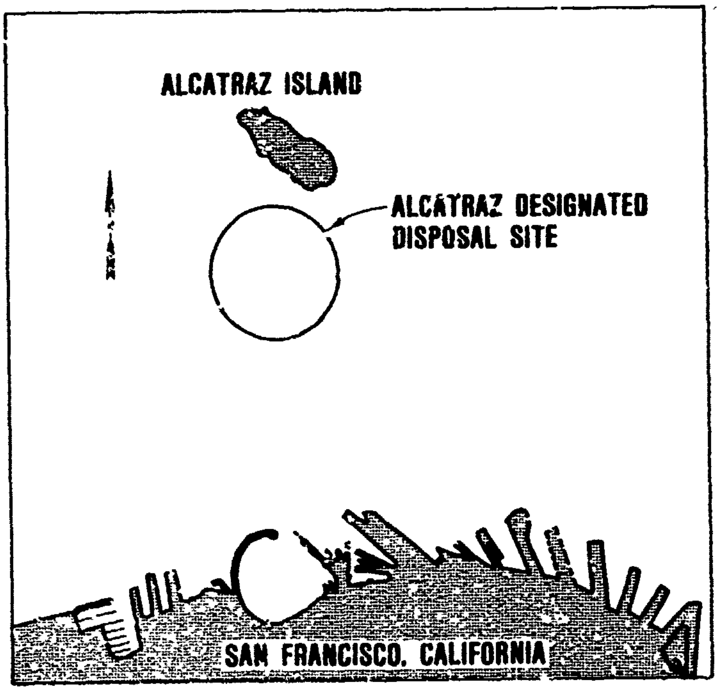
CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
feet	0.3048	metres



a. Location map



b. Vicinity map

Figure 1. Location of Alcatraz disposal site

ALCATRAZ DISPOSAL SITE INVESTIGATION

NORTH ZONE DISPOSAL OF OAKLAND OUTER HARBOR AND RICHMOND INNER HARBOR SEDIMENTS

PART I: INTRODUCTION

Background

1. The Alcatraz dredged material disposal site in San Francisco Bay is a dispersive site that is not intended to accumulate disposed material (Figure 1). The strong tidal currents at the site are expected to transport most of the disposed material from the bay toward the Golden Gate Bridge and out to sea. The disposal site has been in use for over 90 years. Historically, depths within the site have ranged from around 70 ft* to greater than 120 ft mllw.**

2. The recent discovery of shoaling at the site has raised questions about the ability of the site to disperse future new work and maintenance dredged material from bay navigation projects. Mounded material exists throughout the site, resulting in a recent loss of depth to as little as 28 ft in the eastern half of the site (Figure 2). The loss of depth is a problem for two reasons. First, the site is located in the established shipping lane, thus requiring a depth of 40 ft. Second, since this is the only authorized central bay disposal site, abandonment of this site would cause dredged material disposal to become much more expensive if an alternate site were selected and approved that was more distant from dredging sites.

3. An investigation of the short-term fate of material disposed of at the mound location in the eastern portion of the disposal site was conducted by Trawle and Johnson (1986). The objective of that investigation was to estimate quantitatively the capability of the Alcatraz disposal site to disperse dredged material that was disposed of during ebb phase of the tide at the mound location. Specifically, the objective was to estimate both the

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* A table of factors for converting non-SI to SI (metric) units of measurement is presented on page 3.

** All elevations (el) and stages cited herein are in feet referred to mean lower low water (mllw).

percentage of disposed material initially deposited at the disposal site and the percentage of deposited material subsequently resuspended and transported from the disposal site under varying hydrodynamic conditions.

Objective

4. The objective of this study was to predict the initial deposition pattern (short-term fate) for three different dredged materials from a series of hopper dredge disposals in the northern zone of the Alcatraz disposal site (Figure 3) over a complete tidal cycle. Initial deposition refers to the location of material as it first strikes the bottom without consideration of any further transport or resuspension. Short-term refers to a period of time from a few minutes to a few hours, depending on the circumstances of the disposal.

Approach

5. The approach used was to simulate a series of 12 hopper dredge disposals using the mathematical disposal model DIFID (Disposal From Instantaneous Dump) (Johnson, in preparation). The DIFID model simulates the convective descent, dynamic collapse, and initial deposition phases of hopper dredge disposal material for each disposal in the series. The series of disposal simulations was repeated for three different dredged materials.

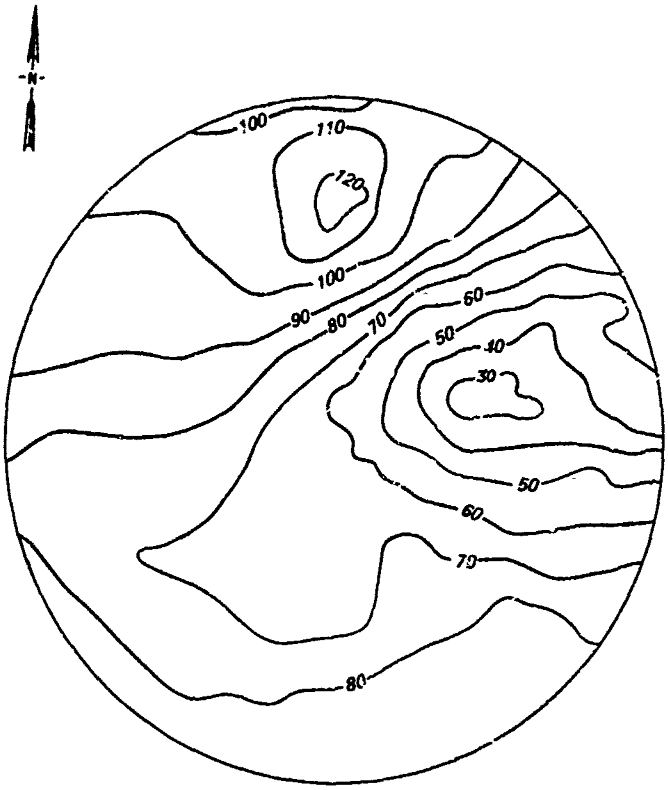

Figure 2. Alcatraz disposal site depth contours from 11 January 1984 survey (soundings in ft)

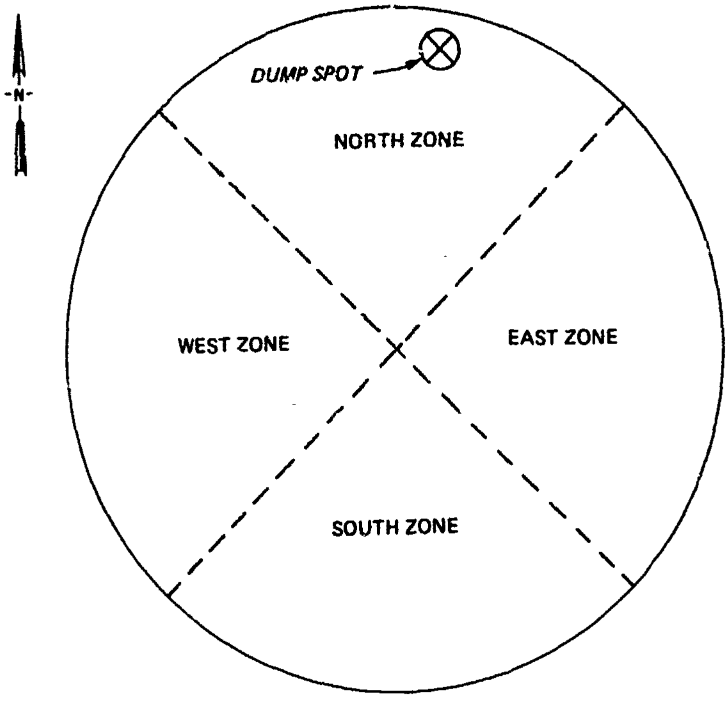

Figure 3. Zone designations for Alcatraz disposal site

PART II: DESCRIPTION OF THE NUMERICAL MODEL DIFID

6. The disposal model DIFID was developed by Brandsma and Divoky (1976) for the US Army Engineer Waterways Experiment Station (WES) under the Dredged Material Research Program. Much of the basis for the model was provided by earlier model development by Koh and Chang (1973) for barged disposal of wastes in the ocean. That work was conducted under funding by the US Environmental Protection Agency laboratory in Corvallis, Oregon. Modifications to the original model have been made by the Hydraulics Laboratory at WES (Johnson, in preparation).

7. The numerical model computes the behavior of a dredged material disposal through three phases: convective descent, during which the disposal cloud falls under the influence of gravity; bottom collapse, occurring when the descending cloud impacts the bottom; and passive transport-diffusion, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation. The model accounts for land boundaries, depth variations, ambient current variations in three spatial dimensions and in time, several sediment classes within the dredged material, and variations of ambient density profiles in time. A detailed description of the model is given by Trawle and Johnson (1986) and will not be presented here. The various model coefficients used for this study are given in Table 1.

PART III: TEST CONDITIONS

Bathymetry

8. The model grid used in this study is shown in Figure 4. Depths at the model grid points within the Alcatraz disposal site were taken from the April 1985 hydrographic survey provided by US Army Engineer District, San Francisco (SPN) (Figure 5). Grid points located in the surrounding vicinity were obtained from a January 1984 hydrographic survey provided by SPN.

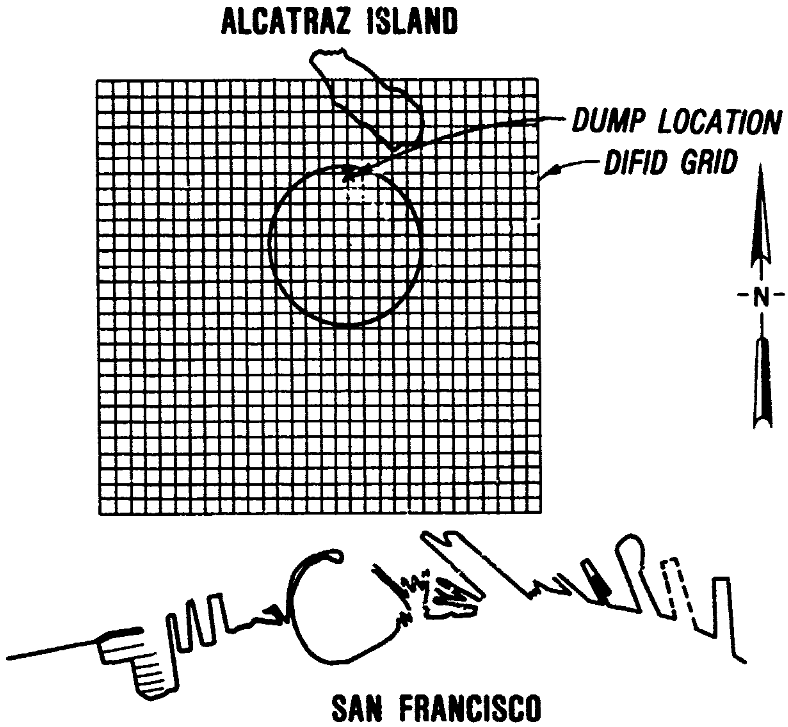

Figure 4. Numerical model (DIFID) grid

Tidal Currents

9. Disposal site current measurements collected in July 1985 were used in this study (Winzler and Kelly 1985). A total of six stations were monitored at the Alcatraz site. Each of these stations was assigned to a portion of the numerical model grid; and by simple conservation of mass, velocities were generated at each grid point in the numerical model. Using this technique, the tidal currents for the northern zone disposal spot were generated and are shown in Figure 6.

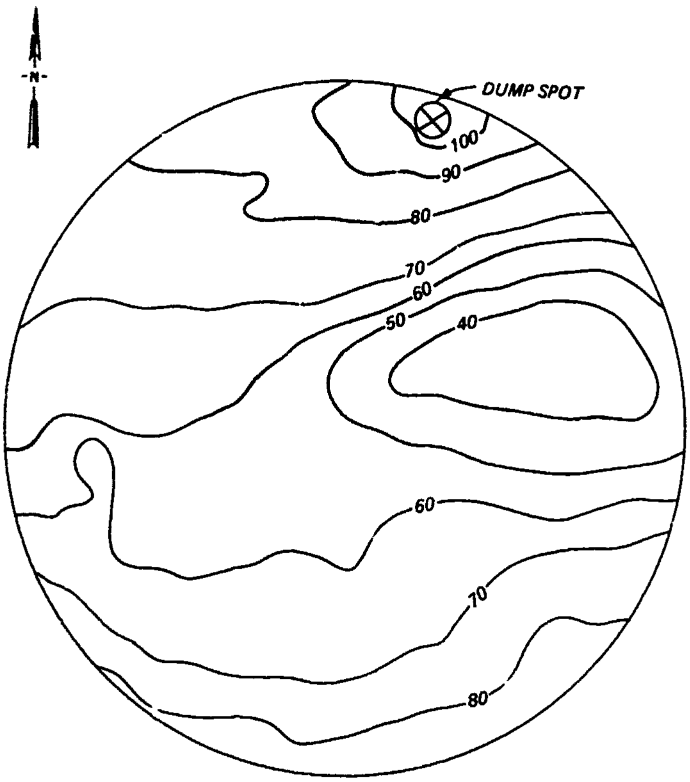

Figure 5. Alcatraz disposal site bottom contours, in ft, from the 12 April 1985 survey

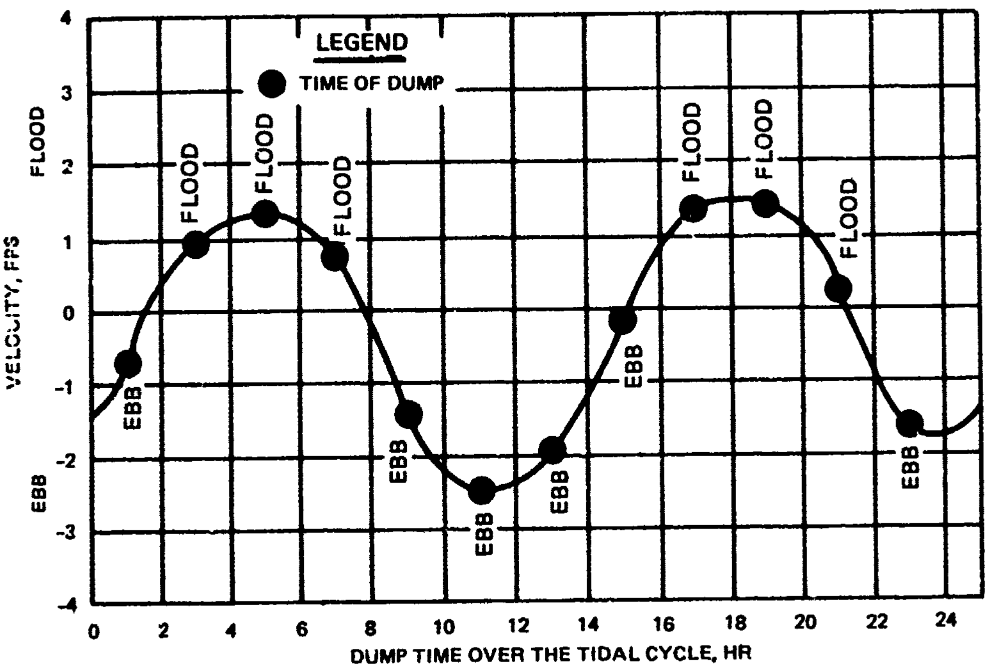

Figure 6. Tidal currents at north zone disposal spot (depth-averaged)

Disposal Sediments

10. The disposal of three different sediments was simulated. Two of the sediments are representative of Oakland Outer Harbor sediments and the third of Richmond Inner Harbor sediment. As specified by SPN, the following fractions of silt-clay and sand were used in DIFID for each of these sediments:

Sediment	Percent			
	Coarse Sand	Medium Sand	Fine Sand	Silt-Clay
Oakland Outer Harbor No. 1	0	4	83	13
Oakland Outer Harbor No. 2	4	7	38	51
Richmond Inner Harbor	0	2.5	7.5	90

11. The bulk density of the hopper dredge slurry for all three sediments was 1.35 g/cc. The following settling velocities were assigned to each sediment fraction:

Sediment Fraction	Settling Velocities, fps
Silt-clay	0.0013
Fine sand	0.0033
Medium sand	0.020
Coarse sand	0.10

Disposal Spot

12. The location for all disposals in this study was in the northern zone of the Alcatraz disposal site, as indicated in Figure 3.

Disposal Times

13. For each sediment, a series of disposals were made (a) over a complete tidal cycle at 2-hr intervals, (b) over the ebbing portion of the tidal cycle only at 2-hr intervals, and (c) over the flooding portion of the tidal cycle only at 2-hr intervals, as shown in Figure 6.

Disposal Size

14. The size for all disposals in this study was 4,000 cu yd, a typical disposal size for hopper dredges used in the bay. The volume of each sediment fraction for the 4,000-cu-yd load for each sediment tested is as follows:

Oakland Outer Harbor Sediment No. 1 (13 Percent Silt-Clay)

Fraction		Volume cu yd
Silt-clay		109
Fine sand		697
Medium sand		34
Water		3,160
	Total	4,000

Oakland Outer Harbor Sediment No. 2 (51 Percent Silt-Clay)

Fraction		Volume cu yd
Silt-clay		428
Fine sand		319
Medium sand		59
Coarse sand		34
Water		3,160
	Total	4,000

Richmond Inner Harbor Sediment (90 Percent Silt-Clay)

Fraction		Volume cu yd
Silt-clay		756
Fine sand		63
Medium sand		21
Water		3,160
	Total	4,000

PART IV: RESULTS

15. To analyze model results, the Alcatraz disposal site was divided into four equal zones, referred to as the north, east, south, and west zones, as shown in Figure 3. The initial deposition of disposed material within each zone for each disposal series simulation was tabulated by zone.

Oakland Outer Harbor Sediment No. 1 Simulations

16. For the complete tidal cycle simulation, the 12 disposals using Oakland Outer Harbor sediment No. 1 included a total of 1,310 cu yd of silt-clay, 8,366 cu yd of fine sand, and 403 cu yd of medium sand, along with 37,920 cu yd of water, totaling 48,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 2.

17. For the simulation of ebb tide only, the 6 disposals using Oakland Outer Harbor sediment No. 1 included a total of 655 cu yd of silt-clay, 4,183 cu yd of fine sand, and 202 cu yd of medium sand, along with 18,960 cu yd of water, totaling 24,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 2.

18. For the simulation of flood tide only, the 6 disposals using Oakland Outer Harbor sediment No. 1 included a total of 655 cu yd of silt-clay, 4,183 cu yd of fine sand, and 202 cu yd of medium sand, along with 18,960 cu yd of water, totaling 24,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 2.

Oakland Outer Harbor Sediment No. 2 Simulations

19. For the complete tidal cycle simulation, the 12 disposals using Oakland Outer Harbor sediment No. 2 included a total of 5,141 cu yd of silt-clay, 3,830 cu yd of fine sand, 706 cu yd of medium sand, and 403 cu yd of coarse sand, along with 37,920 cu yd of water, totaling 48,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 3.

20. For the simulation of ebb tide only, the 6 disposals using Oakland Outer Harbor sediment No. 2 included a total of 2,570 cu yd of silt-clay, 1,915 cu yd of fine sand, 353 cu yd of medium sand, and 202 cu yd of coarse sand, along with 18,960 cu yd of water, totaling 24,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 3.

21. For the simulation of flood tide only, the 6 disposals using Oakland Outer Harbor sediment No. 2 included a total of 2,570 cu yd of silt-clay, 1,915 cu yd of fine sand, 353 cu yd of medium sand, and 202 cu yd of coarse sand, along with 18,960 cu yd of water, totaling 24,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 3.

Richmond Inner Harbor Sediment Simulations

22. For the complete tidal cycle simulation, the 12 disposals using Richmond Inner Harbor sediment included a total of 9,072 cu yd of silt-clay, 756 cu yd of fine sand, and 252 cu yd of medium sand, along with 37,920 cu yd of water, totaling 48,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 4.

23. For the simulation of ebb tide only, the 6 disposals using the Richmond Inner Harbor sediment included a total of 4,536 cu yd of silt-clay, 378 cu yd of fine sand, and 126 cu yd of medium sand, along with 18,960 cu yd of water, totaling 24,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 4.

24. For the simulation of flood tide only, the 6 disposals using the Richmond Inner Harbor sediment included a total of 4,536 cu yd of silt-clay, 378 cu yd of fine sand, and 126 cu yd of medium sand, along with 18,960 cu yd of water, totaling 24,000 cu yd of slurry. The amounts of sediment deposited in each zone by volume and percent of the total amount disposed of are shown in Table 4.

PART V: CONCLUSIONS

25. The initial deposition of disposed material within the Alcatraz disposal site as percentage of material disposed is summarized in the following tabulation:

Type of Sediment	Disposal Cycle Total	Ebb	Flood
Oakland Outer Harbor Sediment No. 1	65	56	72
Oakland Outer Harbor Sediment No. 2	62	54	69
Richmond Inner Harbor Sediment	53	45	62

26. The results from the nine series of simulations show the following:

a. For the total tidal cycle disposal of Oakland Outer Harbor sediment No. 1, 65 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

b. For the ebb tide only disposal of Oakland Outer Harbor sediment No. 1, 56 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

c. For the flood tide only disposal of Oakland Outer Harbor sediment No. 1, 72 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

d. For the total tidal cycle disposal of Oakland Outer Harbor sediment No. 2, 62 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

e. For the ebb tide only disposal of Oakland Outer Harbor sediment No. 2, 54 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

f. For the flood tide only disposal of Oakland Outer Harbor sediment No. 2, 69 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

g. For the total tidal cycle disposal of Richmond Inner Harbor sediment, 53 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

h. For the ebb tide only disposal of Richmond Inner Harbor sediment, 45 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

i. For the flood tide only disposal of Richmond Inner Harbor sediment, 62 percent of the material disposed of at the north zone location was initially deposited within the disposal site.

As can be seen, the initial deposition as a percent of material disposed is significantly reduced if the disposal is restricted to the ebb tide only. However, even for the ebb tide disposals, about half of the disposed sediment can be expected to initially deposit within the disposal site.

REFERENCES

Brandsma, M. G., and Divoky, D. J. 1976 (May). "Development of Model for Prediction of Short-Term Fate of Dredged Material Discharged in the Estuarine Environment," Contract Report D-76-5, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Johnson, B. H. "User's Guide for Dredged Material Disposal Models for Computing the Short-Term Fate at Open-Water Sites" (in preparation), US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Koh, R. C. Y., and Chang, Y. C. 1973 (Dec). "Mathematical Model for Barged Ocean Disposal of Waste," Environmental Protection Technology Series EPA 660/2-73-029, US Environmental Protection Agency, Washington, DC.

Trawle, M. J., and Johnson, B. H. 1986 (Mar). "Alcatraz Disposal Site Investigation," Miscellaneous Paper HL-86-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Winzler and Kelly. 1985 (Sep). "Oceanographic Investigation at the Alcatraz Disposal Site, San Francisco Bay, California," prepared by Winzler and Kelly, Consulting Engineers, San Francisco, Calif., for the US Army Engineer District, San Francisco, San Francisco, Calif.

Table 1

Values for Model Coefficients

Coefficient	Description	Default Value	Value Used
σ_o	Convective descent entrainment	0.235	0.275
β	Settling coefficient	0.0	0.0
CM	Apparent mass coefficient	1.0	0.0
CD	Drag coefficient of sphere	0.50	0.40
δ	Relates cloud density gradient to ambient density gradient	0.25	0.25
CDRAG	Drag coefficient of ellipsoid	1.0	0.50
CFRIC	Skin friction of ellipsoid	0.01	0.01
CD3	Drag coefficient of ellipsoidal wedge	0.10	0.10
σ_c	Collapse entrainment coefficient	0.02	0.02
FRICTN	Bottom friction coefficient	0.01	0.01
FI	Modification factor in bottom friction force	0.10	0.10
ALAMDA	Dissipation parameter, $ft^{2/3}/sec$	0.005	0.005
AKYO	Maximum value of vertical diffusion coefficient, ft^2/sec	0.05	0.05

Table 2

Initial Deposition of Oakland Outer Harbor

Sediment No. 1 by Zone

Sediment Fraction	Amount Disposed cu yd	Amount Deposited per Zone, cu yd North	East	South	West	Total Retained at Site cu yd	percent
		Complete Tidal Cycle Disposal					
Silt-clay	1,310	613	63	0	42	718	55
Fine sand	8,366	4,775	352	0	317	5,444	65
Medium sand	403	369	6	0	15	390	97
Total	10,079	5,757	421	0	374	6,552	65
		Ebb Tide Disposal Only					
Silt-clay	655	263	1	0	32	296	45
Fine sand	4,183	2,122	10	0	222	2,354	56
Medium sand	202	184	1	0	3	187	93
Total	5,040	2,569	12	0	256	2,837	56
		Flood Tide Disposal Only					
Silt-clay	655	338	54	0	10	402	61
Fine sand	4,183	2,622	302	0	109	3,033	73
Medium sand	202	186	5	0	6	197	98
Total	5,040	3,146	361	0	125	3,632	72

Table 3

Initial Deposition of Oakland Outer Harbor

Sediment No. 2 by Zone

Sediment Fraction	Amount Disposed cu yd	Amount Deposited per Zone, cu yd				Total Retained at Site	
		North	East	South	West	cu yd	percent
		Complete Tidal Cycle Disposal					
Silt-clay	5,141	2,283	208	0	173	2,664	52
Fine sand	3,830	2,169	137	0	171	2,477	65
Medium sand	706	646	9	0	29	684	97
Coarse sand	403	398	0	0	4	402	100
Total	10,079	5,496	354	0	377	6,227	62
		Ebb Tide Disposal Only					
Silt-clay	2,570	991	3	0	125	1,119	44
Fine sand	1,915	964	4	0	113	1,081	56
Medium sand	353	320	1	0	18	339	96
Coarse sand	202	197	1	0	3	201	100
Total	5,040	2,472	9	0	259	2,740	54
		Flood Tide Disposal Only					
Silt-clay	2,570	1,312	207	0	41	1,560	61
Fine sand	1,915	1,201	135	0	50	1,386	72
Medium sand	353	327	8	0	10	345	98
Coarse sand	202	199	0	0	2	201	100
Total	5,040	3,039	350	0	103	3,492	69

Table 4

Initial Deposition of Richmond Inner Harbor

Sediment by Zone

Sediment Fraction	Amount Disposed cu yd	Amount Deposited per Zone, cu yd				Total Retained at Site	
		North	East	South	West	cu yd	percent
Complete Tidal Cycle Disposal							
Silt-clay	9,072	3,930	361	0	322	4,613	51
Fine sand	756	444	23	0	29	501	66
Medium sand	252	184	3	0	9	196	78
Total	10,080	4,558	392	0	360	5,310	53
Ebb Tide Disposal Only							
Silt-clay	4,536	1,734	4	0	208	1,946	43
Fine sand	378	200	0	0	18	218	58
Medium sand	126	91	0	0	6	97	100
Total	5,040	2,025	4	0	232	2,261	45
Flood Tide Disposal Only							
Silt-clay	4,536	2,333	354	0	76	2,763	61
Fine sand	378	253	29	0	2	284	75
Medium sand	126	947	3	0	3	100	79
Total	5,040	2,680	386	0	81	3,147	62